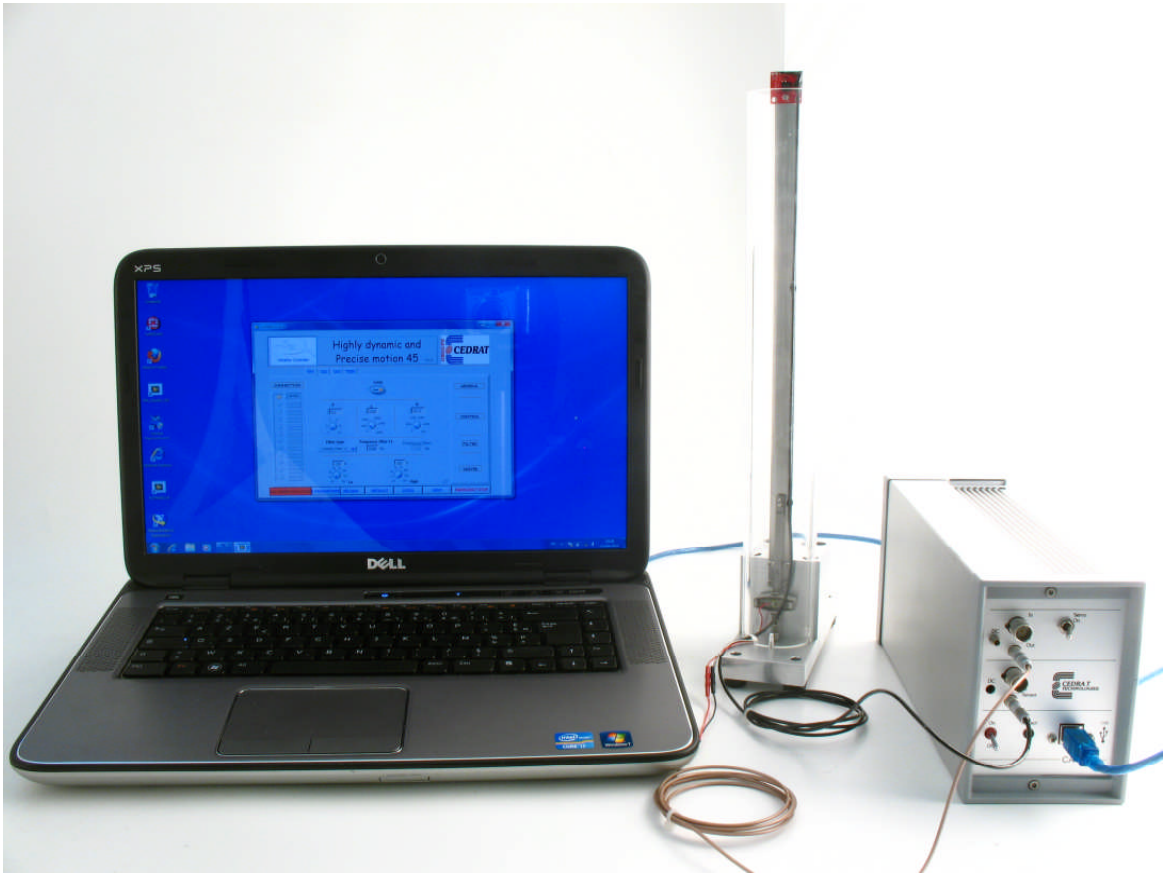
CEDRAT TECHNOLOGIES
Innovation in Mechatronics

# Active Control Of Vibration
# Educational Kit User Manual

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# CAUTION: READ BEFORE OPENING

**For safety purposes these instructions must be read before use of this product.**

**Piezoelectric products are not warranted against mechanical damage resulting from improper use, wherein excessive forces or voltages that are outside specified ranges are applied.**

**High voltage is present in this product.**

**Only qualified personnel should work on or around this equipment and only after becoming thoroughly familiar with all warnings, safety notices, and procedures contained herein.**

**The successful and safe operation of this equipment is dependent on proper handling, installation and operation.**

**A "qualified person" is one who is familiar with the installation, construction and operation of the equipment and the hazards involved. In addition, he/she has the following qualifications :**

- **is trained and authorized to energize, de-energize, clean, and ground equipment in accordance with established practices,**
- **is trained in the proper care and use of protective equipment in accordance with established safety practices.**

Contents

1. Description of the educational kit....4
2. User Manual of APA60SM PIEZO actuATor and CA45 ElectroniC Rack....6
3. INSTALLING THE educational kit....7
3.1. Connecting the hardware....9
3.2. Installing software....7
3.2.1. Required equipments....7
3.2.2. First time installation....7
3.3. Running the Software....10
3.3.1. Introduction....10
3.3.2. Connection Section....11
3.3.3. Parameters section....12
3.3.4. Summary....15
4. Working modes of the eductionnal kit....16
5. Electromagnet Option....17
6. Warranty Conditions and exceptions....17
7. Inspection upon receipt....18
8. After-sale service....18
ANNEX 1 : Trouble Shooting Form....19

# 1. DESCRIPTION OF THE MATERIAL

The Educational Kit includes:

- An Amplified Piezo Actuator APA60SM
- An electronic rack including
  - a linear amplifier CA45
  - a signal conditioner SG75
  - a digital PID controller UC45
- An accelerometer
- A mechanical beam
- Cables
- A GUI interface with USB connection between the PC and the digital controller UC45.

Figure 1 shows a mounted educational kit:

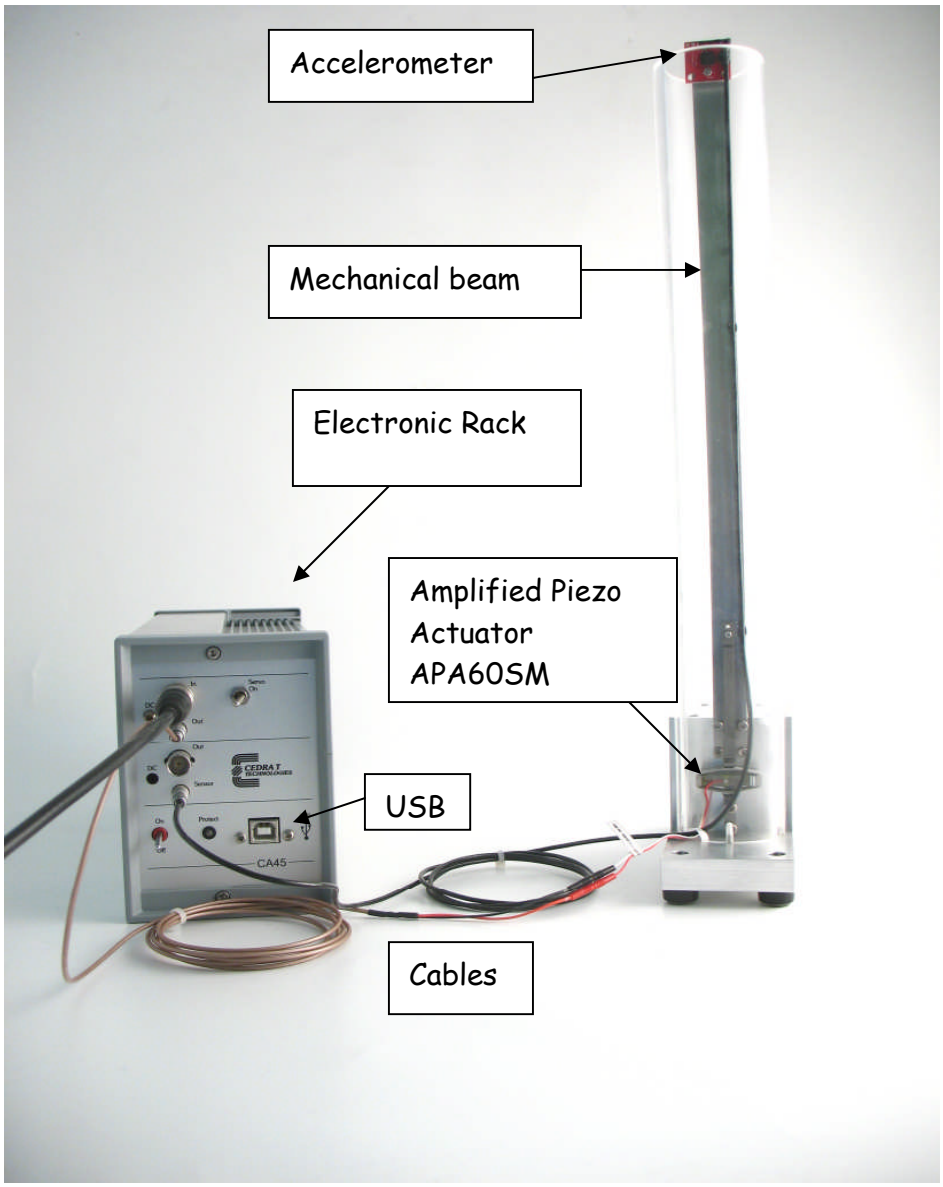



**Figure 1: Educational Kit of Cedrat Technologies**

Figure 2 explains the connections of the CA45 electronic rack:

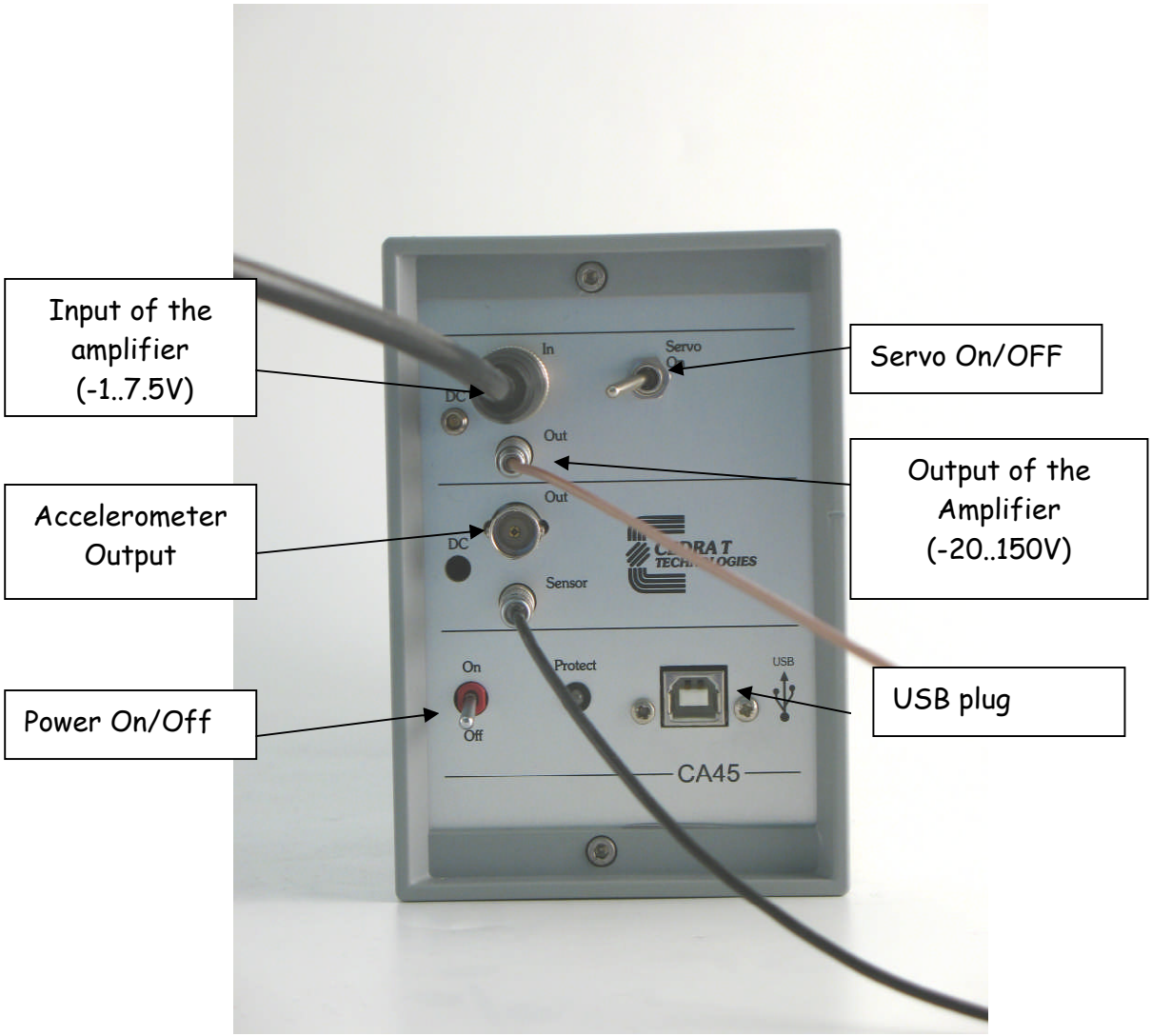



**Figure 2: CA45 Electronic rack description**

Figure 3 shows the GUI Interface of the controller UC45:

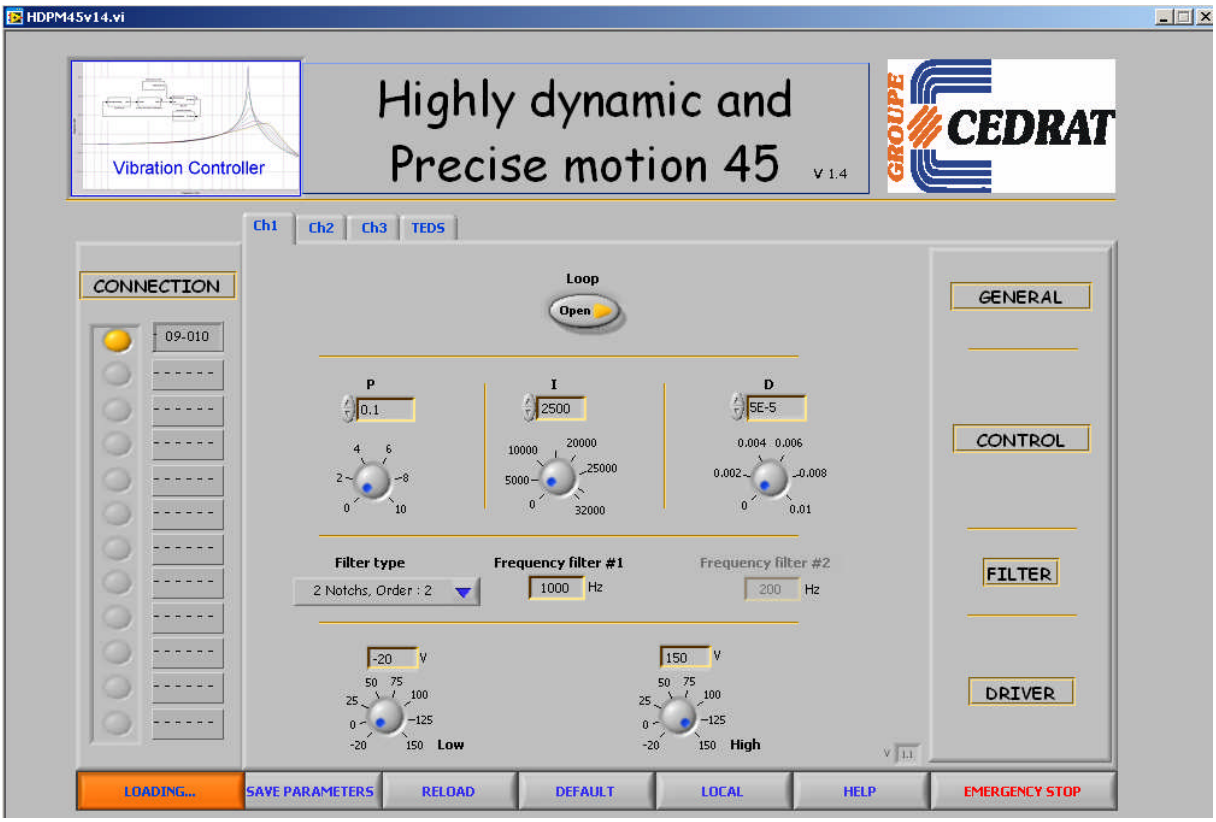



**Figure 3: GUI Interface of the controller (HDPM45.exe)**

Description of the parameters is given in 3.3.3

# 2. USER MANUAL OF APA60SM PIEZO ACTUATOR AND CA45 ELECTRONIC RACK

The APA60SM actuator and the CA45 are standard industrial products of Cedrat Technologies.
The relative user manuals can be found at: http://www.cedrat.com/en/mechatronic-products/user-s-manual.html

# 3. INSTALLING THE EDUCATIONAL KIT

The educational kit is easy and fast to install.

## *3.1. INSTALLING SOFTWARE*

This paragraph describes the different instructions to connect the UC45 microcontroller and to install the software. The operator in the same time must connect the mechanism to the rack following the instruction in the user manual **"LA75 - Linear amplifier for piezoelectric actuators - Product and warranty information"**.

DO NOT CONNECT THE USB DRIVER ON THE PC BEFORE INSTALLING THE SOFTWARE.

### 3.1.1. Required equipments

You must install the Software on the following Personal Computer configuration:

- Change "," in "." in the regional configuration of your PC if it is not the case. (Settings/ Controls Panel / Regional and language Options / Customize / Decimal symbol).
- Your screen cannot be higher than 1200 per 800 pixels.

The installation is simple:

- A unique CD or a download on Cedrat website (http://www.cedrat.com/en/mechatronic-products/software-download.html?0 ) includes the installation of the drivers to dialogue with the UC45 and the installer for the application software. It contains the autonomous application too.

### 3.1.2. First time installation

1. The operator has to run the " setup.exe" , following the giving indications.

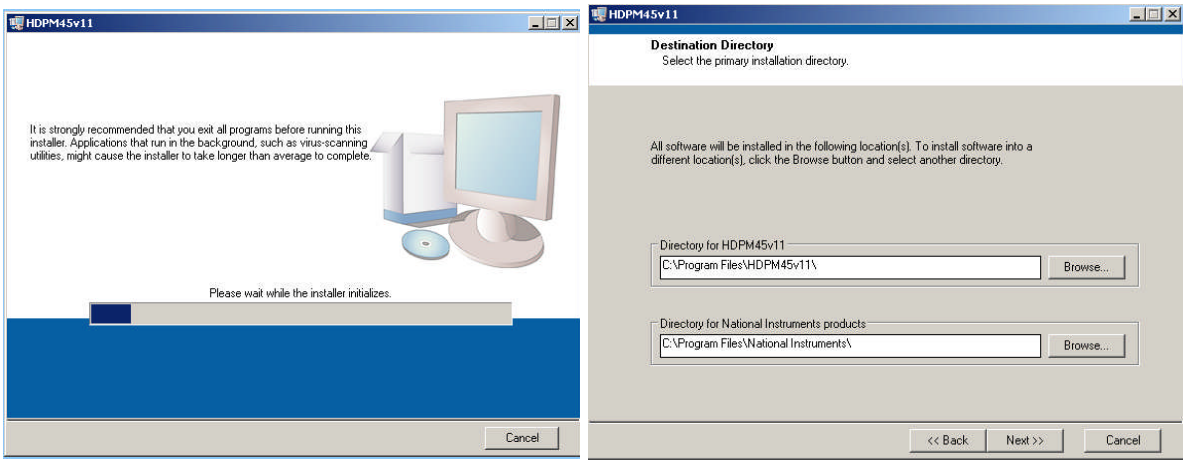

HDPM45v11
It is strongly recommended that you exit all programs before running this installer. Applications that run in the background, such as virus-scanning utilities, might cause the installer to take longer than average to complete.
Please wait while the installer initializes.
Cancel
HDPM45v11
Destination Directory
Select the primary installation directory.
All software will be installed in the following location(s). To install software into a different location(s), click the Browse button and select another directory.
Directory for HDPM45v11
C:\Program Files\HDPM45v11\
Browse...
Directory for National Instruments products
C:\Program Files\National Instruments\
Browse...
<< Back
Next >>
Cancel

**Figure 3-1: Destination directory**

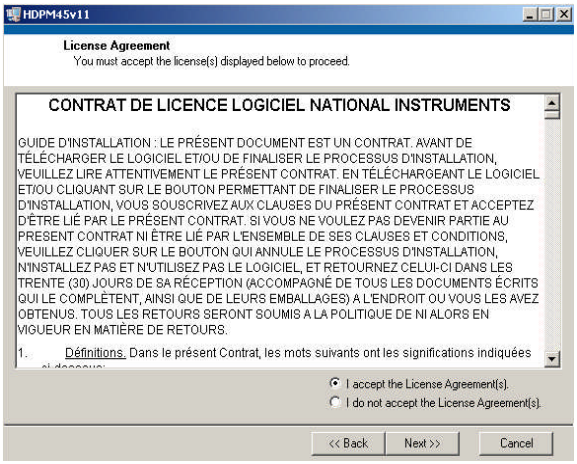

HDPM45v11
License Agreement
You must accept the license(s) displayed below to proceed.
CONTRAT DE LICENCE LOGICIEL NATIONAL INSTRUMENTS
GUIDE D'INSTALLATION : LE PRÉSENT DOCUMENT EST UN CONTRAT. AVANT DE TÉLÉCHARGER LE LOGICIEL ET/OU DE FINALISER LE PROCESSUS D'INSTALLATION, VEUILLEZ LIRE ATTENTIVEMENT LE PRÉSENT CONTRAT. EN TÉLÉCHARGEANT LE LOGICIEL ET/OU CLIQUANT SUR LE BOUTON PERMETTANT DE FINALISER LE PROCESSUS D'INSTALLATION, VOUS SOUSCRIVEZ AUX CLAUSES DU PRÉSENT CONTRAT ET ACCEPTEZ D'ÊTRE LIÉ PAR LE PRÉSENT CONTRAT. SI VOUS NE VOULEZ PAS DEVENIR PARTIE AU PRESENT CONTRAT NI ÊTRE LIÉ PAR L'ENSEMBLE DE SES CLAUSES ET CONDITIONS, VEUILLEZ CLIQUER SUR LE BOUTON QUI ANNULE LE PROCESSUS D'INSTALLATION, N'INSTALLEZ PAS ET N'UTILISEZ PAS LE LOGICIEL, ET RETOURNEZ CELUI-CI DANS LES TRENTE (30) JOURS DE SA RÉCEPTION (ACCOMPAGNÉ DE TOUS LES DOCUMENTS ÉCRITS QUI LE COMPLÈTENT, AINSI QUE DE LEURS EMBALLAGES) A L'ENDROIT OU VOUS LES AVEZ OBTENUS. TOUS LES RETOURS SERONT SOUMIS A LA POLITIQUE DE NI ALORS EN VIGUEUR EN MATIÈRE DE RETOURS.
1. Définitions. Dans le présent Contrat, les mots suivants ont les significations indiquées
I accept the License Agreement(s).
I do not accept the License Agreement(s).
<< Back
Next >>
Cancel

**Figure 3-2 : License Agreement.**

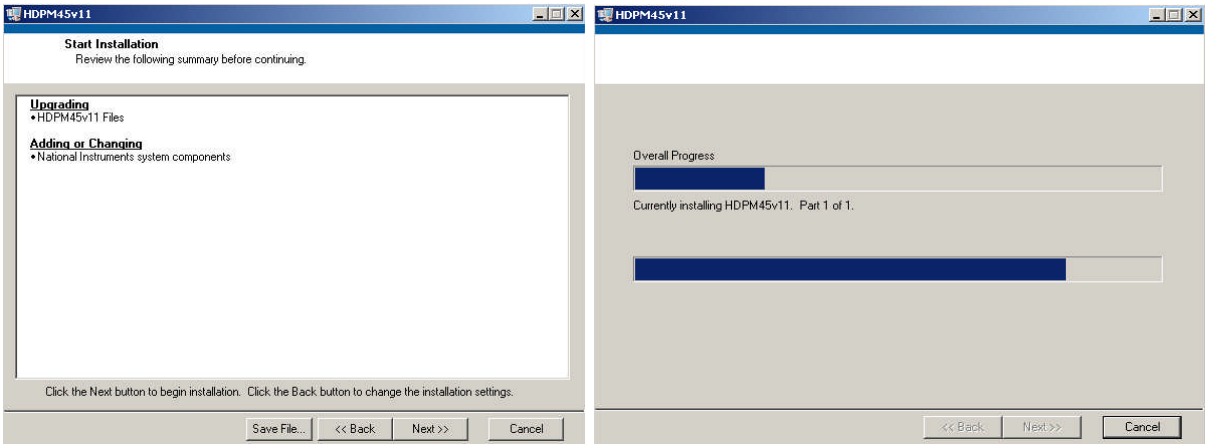



**Figure 3-3: Starting Installation.**

2. After this installation is finished an other driver will be install automatically, and then **restart** your PC.

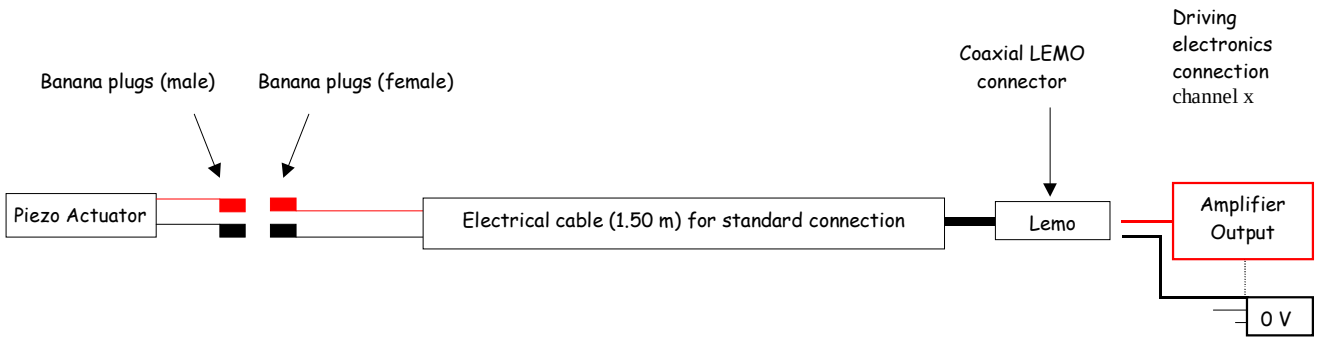
3. Connect your PC with the UC45 by USB cable (see **Erreur ! Source du renvoi introuvable.**) and power on the rack.

4. Now the operator can run the software "HDPM45_vxx.exe" which is normally on your desktop.

## 3.2. INSTALLING THE MATERIAL

Follow the procedure:

1. Connect the CA45 to the grid
2. Connect the brown LEMO cable into the pin "Out" of the CA45 and into the actuator.
   **Respect the colors of the connectors!**
3. Connect the dark LEMO cable into the pin "Sensor".
4. Connect the USB to the PC
5. Do not connect the BNC "In"
6. Switch "Servo On" into the right position
7. Switch ON the CA45. The front LED is green.
8. Open the software HDPM45. The software connects to the controller.
9. The system is ready. By shaking the beam manually, you can observe that the system is damped properly



## *3.3. RUNNING THE SOFTWARE*

### 3.3.1. Introduction

In this paragraph, we describe how to use the "Highly dynamic and precise motion 45" software with a pair piezo actuator/sensor. The software provided with the UC45 permits to command some parameters. At first, the software make a research of the several boards which could be connected. During this first step, a button LOADING… appears. **This first step can be 1 or 2 minutes long.**

**Figure 3-4 :** ***First step***

During a second step, the software will read the parameters on the boards, a button NO COMMUNICATION appears. When those two steps are ok, the Human Machine Interface is ready to use, the button RUNNING appears. The screen is cut in three areas :

- The first one on the left manages the several boards.
- The second one on the right manages the regulator with some parameters that the operator can change.
- The last one on the bottom of the screen includes several main commands to manage the state of the software.

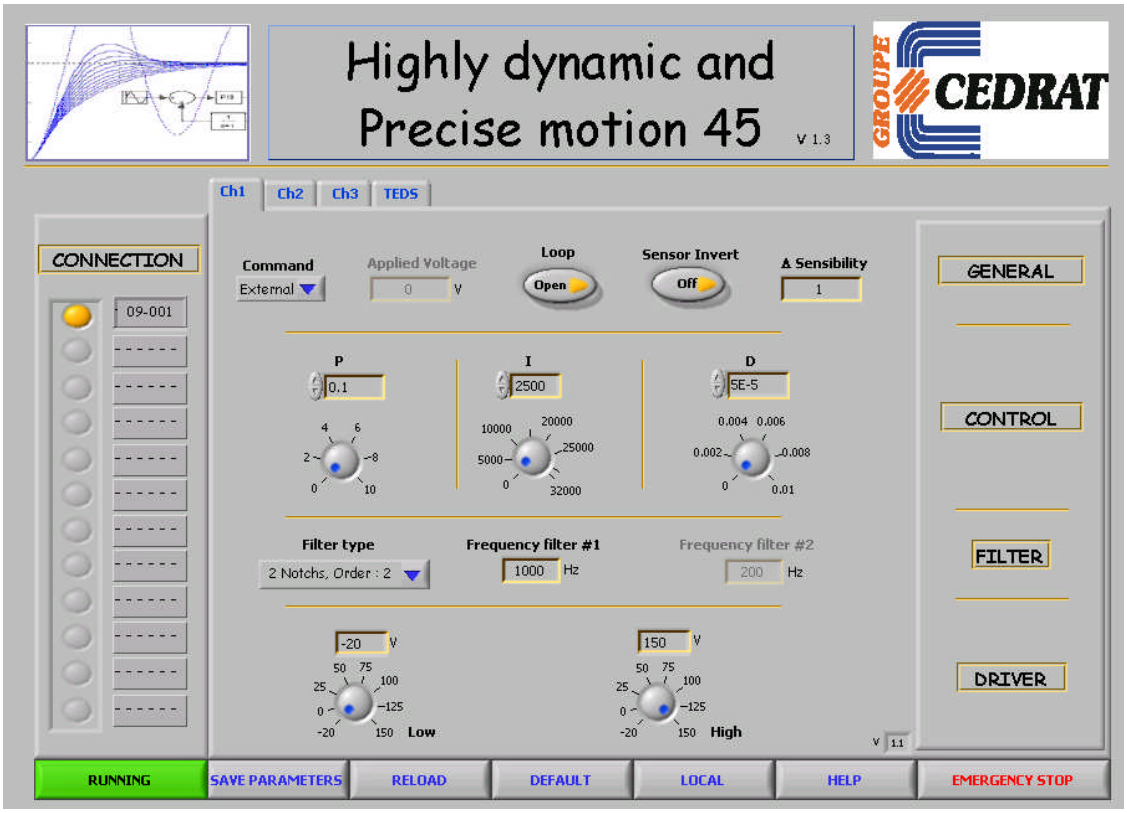



**Figure 3-5 :** ***Human Machine Interface description***

Each section is named which helps the operator to know what kind of parameter is modified.

### 3.3.2. Connection Section

On the left side, the screen is composed of twelve possible boards (maximum number). The software search automatically the boards, and the operator can choose the board he wanted to change the parameters:

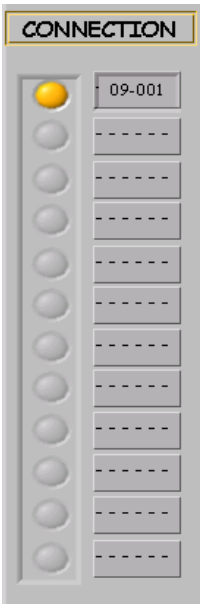



**Figure 3-6 : *Left section of the HMI : Connection section***

Until the connection is not established correctly (button **RUNNING / NO COMMUNICATION** stay in the state **NO COMMUNICATION**), nothing else can be done, excepting **EMERGENCY STOP**.

### 3.3.3. Parameters section

On the right side, the screen is composed of four sections where the operator could pass different parameters for the numeric PID controller:

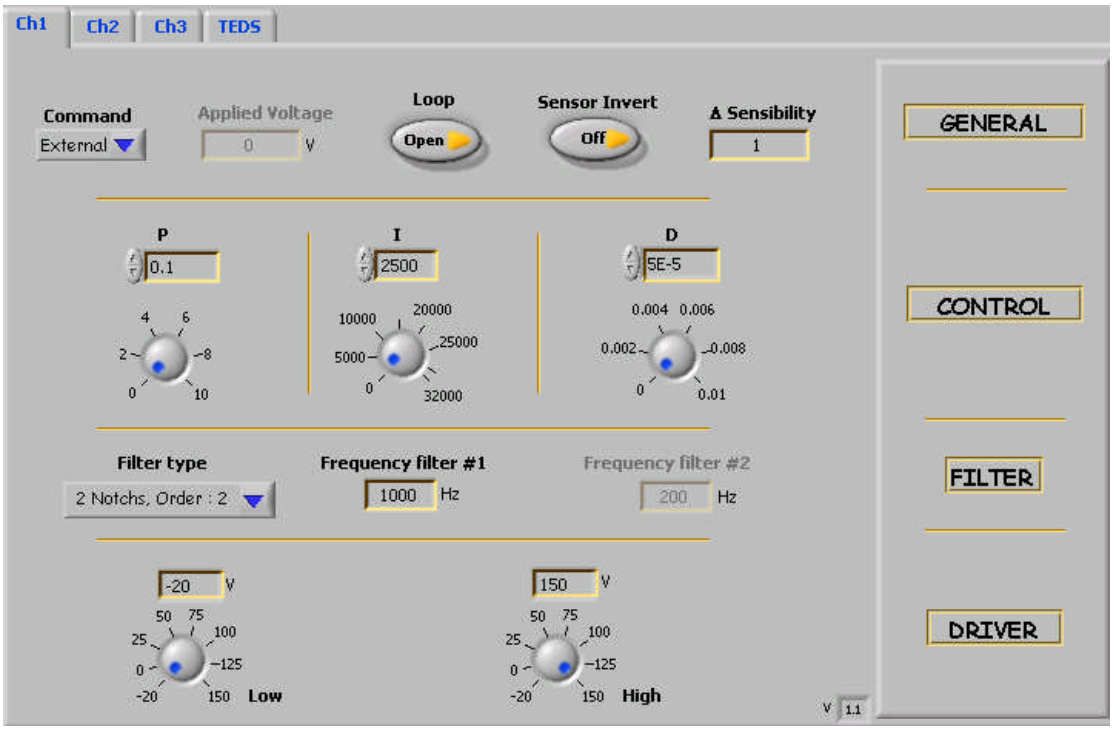


**Figure 3-7 :** ***Right section of the HMI: parameter section***

## GENERAL:

- **Command** is a selector to chose between two possible command to send to the actuator:
  - **Internal**: In this case the command is issued from the **Applied voltage command**. The operator can select the voltage that he would like to send on the actuator between -1 to 7.5 Volts.
  - **External**: In this case the command is issued from the Input BNC connector of the CA45 to command the actuator. This command must be adjusted between -1 to 7.5 Volts.
- **Applied voltage command** is used to send on the actuator directly a static command in Volt between -1 to 7.5V.
- **OL/CL** is a command to close or to open the control loop: OL indicates that the controller works in open loop and CL indicates that the controller works in closed loop (i.e. the regulator is on with the parameters in the control section)
- **Sensor Invert** is used to invert the data's sensor.
- **Δ Sensibility** is used to adjust the sensibility of the data's sensor.

## CONTROL:

- **P, I, D** commands adjust the PID parameters as described in the previous paragraphs.
  - The **P** parameter can be adjusted between 0 to 10 by step of $1^{e-5}$.
  - The **I** parameter can be adjust between 0 to 32000 by step of $1^{e-5}$.
  - The **D** term can be adjusted between 0 to 1e-2 by step of $1^{e-5}$.

The command can be sent by rotating the button or by writing the number independently.

## FILTER:

- **Filter type** indicates the kind of filter is inline with the PID regulator:
  - **Low pass, Order: 2** is a filter based on a $2^{nd}$ order low pass filter. In this case only the **frequency filter #1** can be change.
  - **Notch, Order: 2** is a filter based on a $2^{nd}$ order stop band filter. In this case only the **frequency filter #1** can be change.
  - **Notch, Order: 4** is a filter based on a $4^{th}$ order stop band filter. In this case only the **frequency filter #1** can be change.
  - **2 Notches, Order: 2** are two filters based on a $2^{nd}$ order stop band filter. In this case the **frequency filter #1** and the **frequency filter#2** can be change.
  - **None** indicates that no filter is added with the PID controller.
- **Frequency filter #1, #2** are integers and can be adjust between 50 to 2000 Hz.

## DRIVER:

- **Low** indicates the lowest limitation of the voltage output of the driver.
- **High** indicates the highest limitation of the voltage output of the driver.

The limitation can be adjusted between -20 to 150V.
These values are correct if the offset of the driver is adjusted at 0 Volt. To verify place the **command** in the **internal** mode (section **General**) and check the value of the driver with an oscilloscope. Turn if necessary the offset potentiometer of the CA45 (see user manual of CA45 for additional information).

**We recommend when you tune the regulator to place the Low and High commands with small amplitudes (typ. (-20V, +20V)) to limit a potential risk of damage on the actuator during an instability phase by limiting the amplitude of the applied voltage on the actuator.**

Each channel can be selected and modified with the Channel button. In a 3 channels configuration the operator can select independently the parameters of each channel for the **GENERAL**, **CONTROL**, **FILTER** and **DRIVER** sections.

### 3.3.4. Summary

Each parameter are summarized in the following table including their states.

| Name | Range |
|---|---|
| **Connection Section** | |
| COM | 1 to 12 |
| **Parameters Section** | |
| Command | Internal: Command from HMI / External: Command from BNC |
| Applied Voltage | -1 to 7.5V in Internal mode |
| OL/CL | OL: Open loop / CL: Closed Loop |
| Sensor Invert | On : data's sensor invert / Off : data's sensor not invert |
| Δ Sensibility | 0 to 10 – resolution 1e-5 |
| P | 0 to 10 - resolution 1e-5 |
| I | 0 to 32000 - resolution 1e-5 |
| D | 0 to 1e-2 – resolution 1e-5 |
| Filter type | Low pass, Order : 2<br>Notch, Order : 2<br>Notch, Order : 4<br>2 Notchs, Order : 2<br>None |
| Frequency filter #1 | Frequency of the filter number 1 – 50 to 2000Hz |
| Frequency filter #2 | Frequency of the filter number 2 – 50 to 2000Hz |
| Low | -20 to 150V |
| High | -20 to 150V |
| **TEDS** | |
| Serial Number – UC45 | |
| Channel – UC45 | |
| Sensor | SG75/ECS75 |
| Serial Number of sensor | |
| Last Calibration | DD/MM/YYYY |
| Calibration Period | month |
| SNR in dB | |
| Low cut off frequency | at -3dB in Hz |
| High cut off frequency | at -3dB in Hz |
| Calibration for SG75 | Strain Gages gain (µm/V);<br>Amplifier Gain (V/V);<br>System Gain (µm/V) |
| Calibration for ECS75: | Gain in µm/V;<br>Linearity error in % |
| **General command section** | |
| RUNNING / NO COMMUNICATION | Display the state of the communication between the PC and the boards. |
| SAVE PARAMETERS | Save the parameters at the screen. |
| RELOAD | Call back the parameters from the SAVE PARAMETERS action. |
| DEFAULT | Call back initial parameters. |
| HELP | Display a short form of the user manual |
| LOCAL / REMOTE | REMOTE: The USB link is disable and the HMI is disconnected from the UC45 controller / LOCAL: The USB link is enable and the HMI is connected to the UC45 controller |
| EMERGENCY STOP | Stop the software |

# 4. WORKING MODES OF THE EDUCTIONNAL KIT

The educational kit can operate in 2 working modes.

## *4.1. FIRST WORKING MODE: ACTIVE CONTROL OF VIBRATIONS*

The first mode is in closed loop. The input of the electronics (reference signal) is null (see Figure 8). The systems controls and damps the vibrations of the beam.

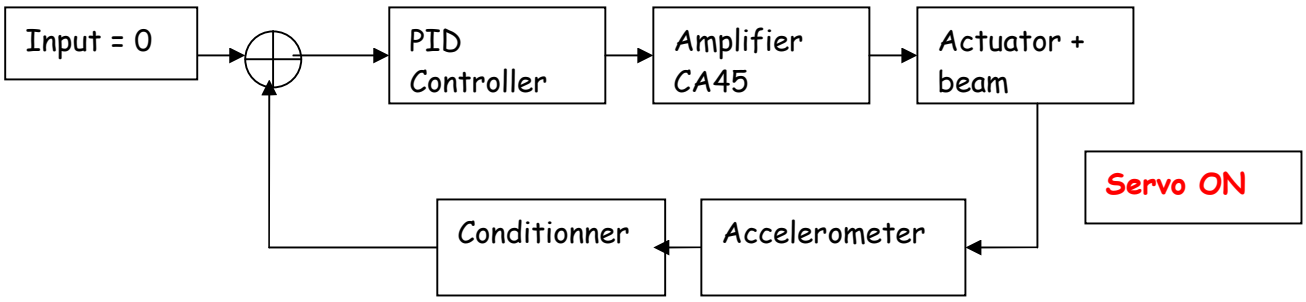



**Figure 8: First working mode of the educational kit (Active Control of Vibrations)**

## *4.2. SECOND WORKING MODE: FORCED EXCITATION OF THE BEAM WITH THE PIEZO ACTUATOR*

The second mode is in open loop. The piezo actuator is used as a forced exciter of the beam (see Figure 9).
The input of the electronics is a sine wave between 0V and 3V. The control is switched off (SERVO OFF). The beam oscillates at the frequency of the sine wave under the action of the piezo actuator. The amplitude is proportional to the input voltage. It is possible to make a sweep in frequency. **Be careful to resonances!!**

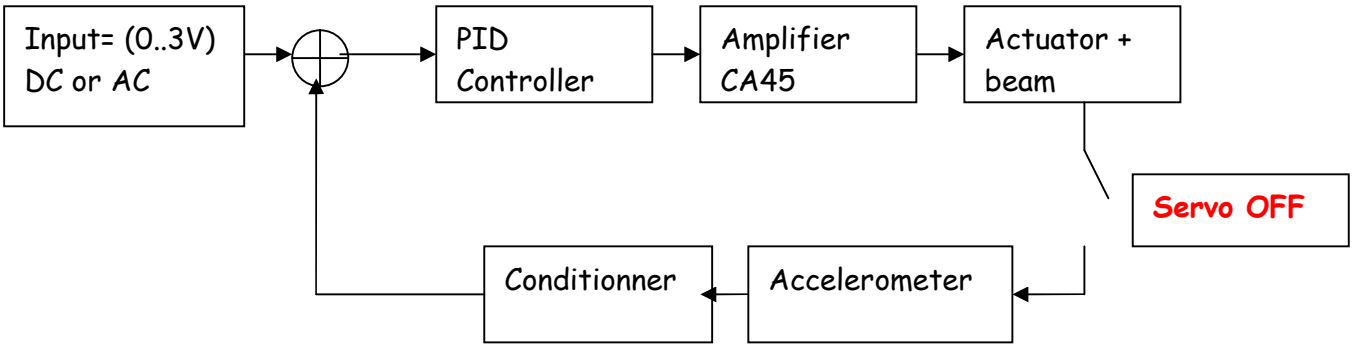



**Figure 9: Second working mode of the educational kit (Forced Excitation of the beam)**

# 5. ELECTROMAGNET OPTION

In construction…

# 6. WARRANTY CONDITIONS AND EXCEPTIONS

The equipment is warranted for a period of one year from date of shipment, including parts and labor, and only under standard technical conditions as outlined above and expressly mentioned in the technical data sheet. Repairs will be carried out at Cedrat Technologies or through your vendor. During the warranty period, Cedrat Technologies will, at its option, either repair **or** replace products which prove to be defective.

**Interventions or attempts to service or repair the Actuators by any unauthorized persons will invalidate this warranty.**

In addition, this warranty will not apply if the actuator is subjected to any of the following:

- improper handling, including, but not limited to, shocks and abrasions
- improper installation, including, but not limited to, excessive mechanical forces and moments, failure to use the standard electrical and mechanical interfaces
- excessive voltage, including, but not limited to, peak values outside the recommended operating range, DC values applied for excessive time periods
- inappropriate environmental conditions, including, but not limited to, high temperatures or high humidity
- attempt to modify the standard electrical connection of the APA (soldering out of electrical wires, plugs change,…) or the standard mechanical interfaces

No other warranty is expressed or implied. Cedrat Technologies specifically disclaims the implied warranties of merchantability and fitness for a particular purpose

# 7. INSPECTION UPON RECEIPT

This product has been inspected and shown to operate correctly at the time of shipment, as verified by the Factory Verification form that accompanies the actuator.

Immediately upon receipt of the product, it should be inspected carefully for any signs of damage that may have occurred during shipment. If any damage is found, a claim should be filed with the carrier.

The package should also be inspected for completeness according to the enclosed packing list. If an order is incorrect or incomplete, contact your distributor.

# 8. AFTER-SALE SERVICE

If a device requires service, please contact Cedrat Technologies or your local vendor. Please include the device model and serial number in all correspondence with Cedrat Technologies or your vendor.

# ANNEX 1 : TROUBLE SHOOTING FORM

In case of trouble or breakdown with the piezo actuator,
- please check the electrical impedance (capacitance and insulation resistance) of the actuator and communicate it to your vendor.

This form must be completed by the customer in order to :
- allow Cedrat Technologies to authorise the product return back to the factory,
- help Cedrat Technologies in repairing it.

**Product:** Please give mention here the references and delivery date,

**History:** Please summarise here every action which has been performed with the device since the delivery,

**Problem description:** Please describe here the problems